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ARCHIMEDEAN SCREW TRACTOR MONITORING

Thunder Bay, Ontario

VB COOK CO LIMITED CONSULTING ENGINEERS

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17. Abstract

During the spring of 1982, tests were conducted using an Archimedean Screw Tractor (AST) developed by Mitsui of Japan as an ice management tool for the port of Thunder Bay, Ontario. The vehicle was used in a variety of roles to break the ice, including using its own weight. As part of the evaluation of this craft, V.B. Book Co. Ltd. was tasked with monitoring its performance during the period of operation. This report presents the results of these observations.

Considering the thickness and strength of ice experienced in Thunder Bay, the capability of this prototype AST as an icebreaking device is limited.

The ability of the AST to provide a stable work platform under a variety of water and ice conditions, in conjunction with its ability to develop drawbar pull equal to its own weight, makes it an ideal vehicle from which to implement ice control techniques. Also, it has attractive potential as a rescue vehicle.

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17. Résumé

Au printemps de 1982, le CDT a parrainé les essais d'un véhicule amphibie à vis d'Archimède, mis au point par la firme japonaise Mitsuit pour la lutte contre les glaces dans le port de Thunder Bay. Ces essais ont porté sur la capacité de l'appareil à hâter la fonte des glaces et à briser celles-ci sous son propre poids. Le contrôle suivi de la performance du véhicule et des résultats obtenus a été confié à V.B. Cook Co. Ltd. Le rapport dont il est question ici présente les résultats des observations faites par cette société pour les besoins de l'évaluation du véhicule.

La capacité à briser la glace du prototype essayé semble limitée, du moins si l'on s'en tient à l'épaisseur et à la résistance de la glace qui se forme dans le port de Thunder Bay.

Par contre, l'appareil est capable d'un effort de traction au crochet égal à son propre poids, ainsi que d'une grade stabilité dans toutes sortes de conditions d'évolution dans les glaces et en eau libre. Cela en fait un bâtiment tout indiqué pour la mise en oeuvre de divers moyens de lutte contre les glaces et, possiblement, pour les opérations de sauvetage.

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CONSULTING ENGINEERS

THUNDER BAY, ONTARIO

DISCLAIMER

The contents of this report reflect the views of the Engineer and not necessarily the official views or policies of the Transport Canada Transportation Development Centre.

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and others

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The author wishes to acknowledge the kind assistance of Mr. Jason Edworthy of Artec Canada Ltd. for his technical information and assistance. The assistance of all other parties who helped with the evaluation is also greatly appreciated.

SUMMARY

Considering the thickness and strength of ice experienced in Thunder Bay, the capability of this prototype AST as an ice breaking device is limited.

The ability of the AST to provide a stable work platform under a variety of water and ice conditions in conjunction with the ability to develop drawbar pull equal to its own weight, makes it an ideal vehicle from which to implement ice control techniques. Also it has very attractive potential use as a rescue vehicle.

The operation and performance of the AST was observed and qualatatively evaluated in terms of Implementation of Passive Ice Management Techniques, Icebreaking Capability and potential as an emergency vehicle.

It is concluded that in spite of the limited icebreaking capability of this prototype (future prototypes may be better suited to this application) it, nevertheless, has much potential as an all purpose winter harbour vehicle.

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1. INTRODUCTION

At the request of Transport Canada Transportation Development Centre, and in co-operation with The Lakehead Harbour Commission, Arctec Canada Limited demonstrated a prototype vehicle called the Archimedean Screw Tractor at Thunder Bay, Ontario, during March, 1982.

In order to evaluate the performance of the Archimedean Screw Tractor (AST), this study was undertaken.

This report describes observations of the demonstration and some of the tests applied to the tractor.

V. B. Cook Co. Limited, Consulting Engineers, were engaged to provide monitoring and to report on the performance of the AST and to comment on its suitability as an ice control tool at Thunder Bay.

After discussion with Messrs. J. Edworthy, D. Miller and K. Butt of Arctec Canada, it was decided that monitoring of the demonstration and testing would be done in two parts.

The first part observed the use of the AST to exploit various combinations of passive ice management techniques. This took place in the Thunder Bay harbour approximately midway between the breakwater and the Thunder Bay Keefer Terminal.

The second part observed ice breaking tests by the AST, both unassisted and in conjunction with capability extending practices such as prestressing and slotting the ice. This part took place in and around the Cargill slip at Thunder Bay.

2. MAIN TEXT

2.1 AST Description

The Archimedean Screw Tractor is an amphibious vehicle which is well adapted to movement on snow, ice, broken ice and open water.

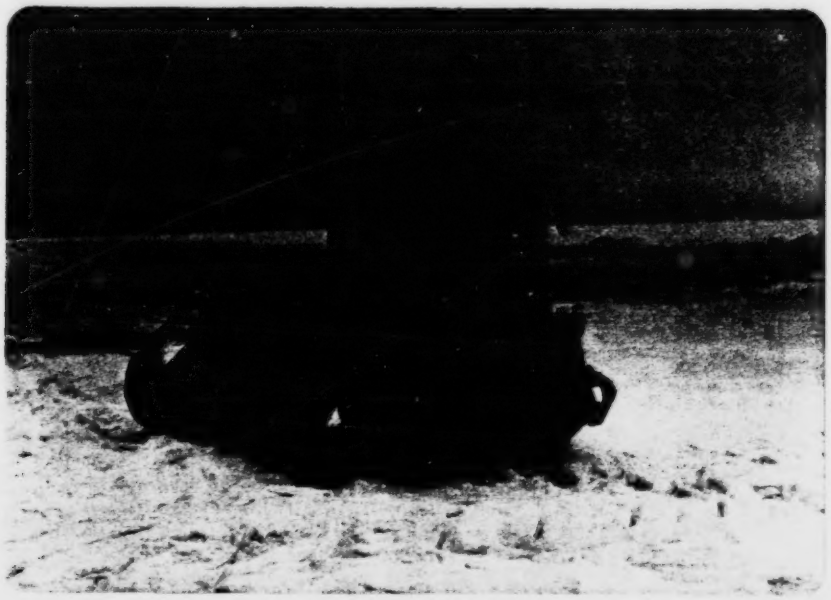
The Arctec organization have developed the AST since 1974 and were able to have two prototypes built, the 001 (1.6 tonne) in 1978 and the 002 (11 tonne) in 1979.

Both prototypes were built by Mitsui Engineering & Shipbuilding Co. Ltd., Tokyo, Japan.

The present trials being conducted on the AST (of which this study is one) are conducted under joint funding by Transport Canada Transportation Development Centre, Petro-Canada and Mitsui Engineering & Shipbuilding Co. Ltd.

2.1.1 Propulsion

Two cylindrical screw rotors propel the AST and buoy the craft when in water. (See Figure 1).



Mitsui AST - Archimedean Screw Tractor
Figure No. 1

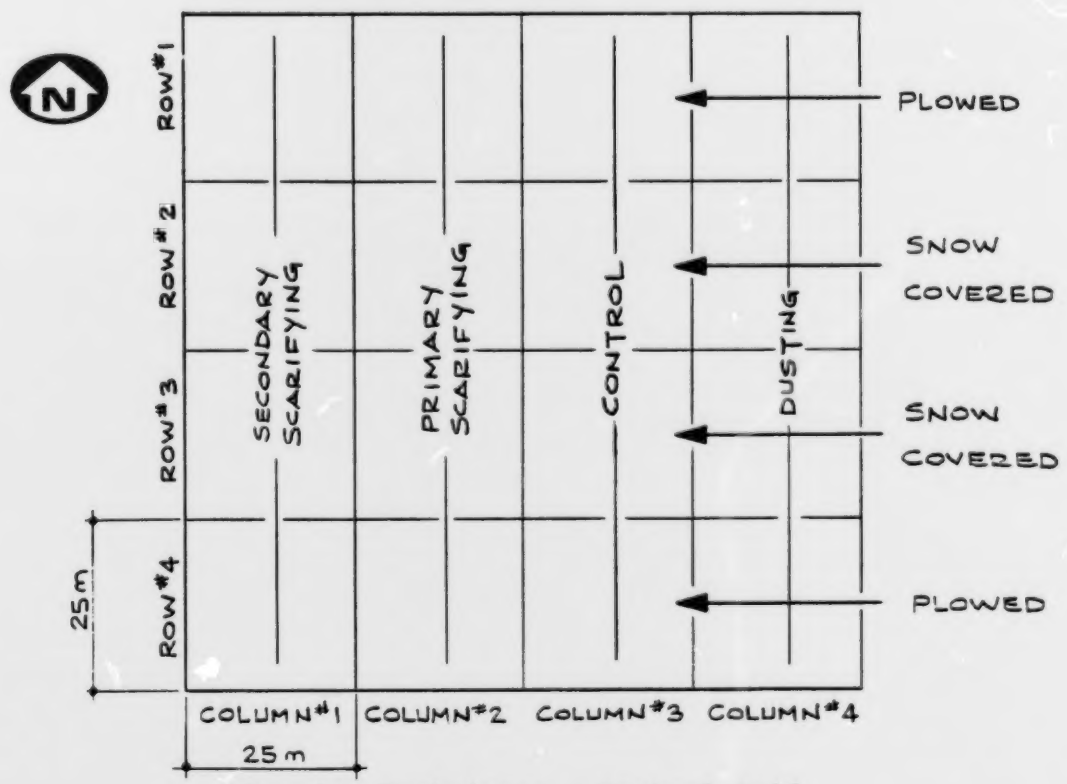
The main hull of the AST houses the control cockpit, propulsion motor and drive system as well as the fuel tanks.

The craft manoeuvers by rotating, slowing, stopping or reversing either or both rotors.

2.2 Procedure & Observations

2.2.1 Passive Ice Management Control Techniques

The AST was used to establish a 16 part square grid. Each square was 25m x 25m, as shown in Figure 2.



Passive Techniques - Control Grid
Figure No. 2

Columns 1 and 3 were left untouched to establish the effect of snow cover. Columns 2 and 4 were plowed to establish the effect of plowing.

Row No. 1 was left unaltered to provide experimental control of snow and bare ice without application of additional techniques.

Row No. 2 was dusted with grain dust to study the combination effect of dusting with snow cover and with bare ice.

Rows No's. 3 and 4 were scarified (gouged) in single (No. 3) and double (No. 4) passes to study the combined effect of scarifying with snow covered and bare ice.

A detailed discussion of the results of these techniques will be reported by Arctec Canada.

The utility and capability of the AST to plow and scarify, and to transport personnel to implement these passive ice management techniques was excellent. The tractor performed well at any task requiring the pulling of heavy equipment or transporting over the ice of personnel and equipment. Additionally, the potential danger associated with breaking through the ice was eliminated because the craft floats and could rescue anyone who might fall through the ice.

2.2.2 Part Two: Ice Breaking Capability

The ice breaking capability of the AST was tried in the mouth of the Mission River and in the Cargill slip.

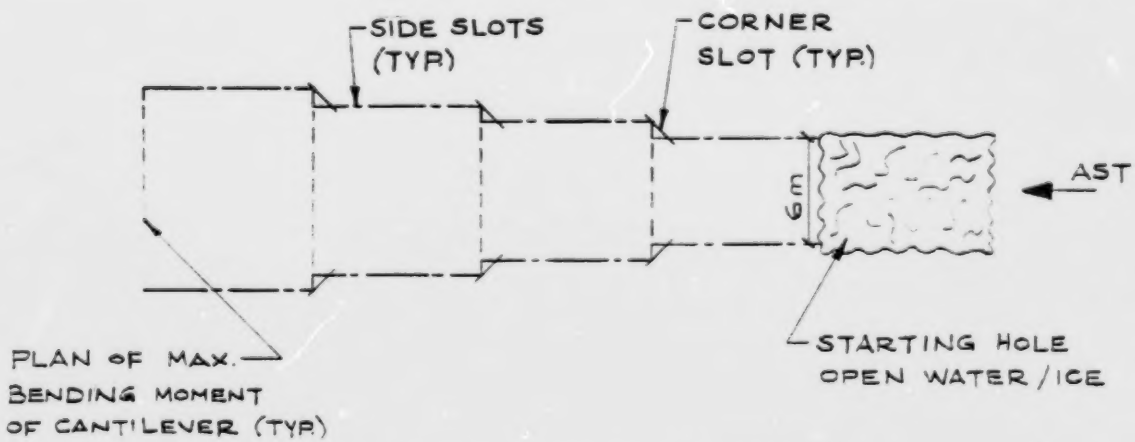
The AST was able to break ice at the mouth of the Mission River by climbing from the water directly onto the ice cover and also by running parallel to the edge of the ice. The ice thickness at the site of this test ranged from 0.4m to 0.5m thick. It is estimated that the rate of ice breaking was approximately 0.02 km^2 per hour.

In the Cargill slip, the AST was able to manoeuvre with ease on the ice cover of the slip but was unable to break ice.

A "Ditch Witch" trenching unit (see Figure No. 3) was used to slot the ice cover to isolate specific widths of ice beams for ice breaking experiments.

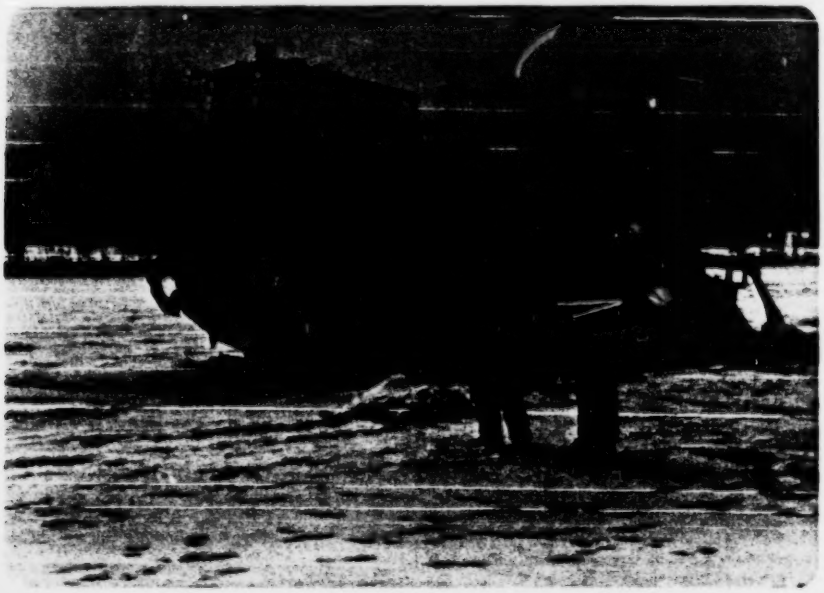
"Ditch Witch" Trenching Unit
Figure No. 3

The slots were spaced at successively larger widths forming cantilever ice beams of successively larger strengths. (See Figure No. 4).



Cantilevered Ice Beams by Slotting
Figure No. 4

The AST was able to break the ice beams at 6 and 8 meters in width, but was stalled at larger widths. (See Figure No. 5). The average ice thickness was approximately 0.7m.



AST Breaking Cantilevered Ice Beams
Figure No. 5

Further quantitative analysis and interpretive discussion of this portion of the experiment are to be included in a report by Arctec Canada.

3. CONCLUSIONS

The seasonal ice thickness growth in Thunder Bay harbour proved to be outside the ice breaking capability of the Archimedean Screw Tractor. However, it can be used to break ice when augmented by other procedures such as slotting or air bubbler suppression. It is our understanding that future production models of this tractor are planned to be larger in size. The increased weight will probably improve its ice breaking capabilities, however, it remains unknown if this would be significant to meet Thunder Bay harbour conditions.

The principle strengths of the craft are threefold.

The first is the ability of the craft to travel with equal ease in water, on ice and, most impressively, through broken, ice congested channels. The propulsive system is efficient, durable and simple.

The second strength is inherent in the design of the craft as a unit. The unit provides, under all conditions, a stable and safe working platform, from which experiments, ice management techniques and ice related rescues can be successfully mounted.

The third strength is a result of the combination of the weight of the craft with the configuration of its propulsion system, the Archimedean Screws. These two factors combine to give the craft a tremendous drawbar pull on ice.

4. REFERENCES

Air Bubbler Ice Control Experiment in Thunder Bay, Ontario. Kamo, H. R. & Nelson, D. A., V. B. Cook Co. Limited, Consulting Engineers, March, 1982.

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